(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 597 853 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
20.03.2002 Bulletin 2002/12

(21) Application number: **91913622.6**

(22) Date of filing: **22.07.1991**

(51) Int Cl.7: **G02F 1/01**

(86) International application number:
PCT/US91/05055

(87) International publication number:
WO 93/02380 (04.02.1993 Gazette 1993/04)

(54) AUTOMATIC LIGHT VALVES

AUTOMATISCHE LICHTVENTILE

MODULATEURS AUTOMATIQUES DE LUMIERE

(84) Designated Contracting States:
AT BE CH DE DK ES FR GB GR IT LI LU NL SE

(43) Date of publication of application:
25.05.1994 Bulletin 1994/21

(73) Proprietor: **CHAHROUDI, Day**
Placitas, NM 87043 (US)

(72) Inventor: **CHAHROUDI, Day**
Placitas, NM 87043 (US)

(74) Representative:
Cheyne, John Robert Alexander Mackenzie et al
Haseltine Lake & Co.,
Imperial House,
15-19 Kingsway
London WC2B 6UD (GB)

(56) References cited:

EP-A- 0 181 485	US-A- 3 953 110
US-A- 4 085 999	US-A- 4 260 225
US-A- 4 307 942	US-A- 4 722 595
US-A- 4 832 466	US-A- 4 877 675
US-A- 4 881 798	US-A- 4 900 135
US-A- 4 952 035	

EP 0 597 853 B1

Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] This invention relates to improved structures for light, valves and the methods of manufacture necessitated by these improved structures.

Brief Description of the Prior Art

[0002] Previously, most light valves have been based on mechanical and/or electrical operation. For example, the means for varying the amount of sunlight admitted into buildings includes curtains, venetian blinds, seasonal paint for greenhouses, and skylids. Skylids are automatic mechanical shutters which are actuated thermally by sunlight. Mechanical light valves for buildings are surveyed in "Thermal Shutters and Shades" by W. A. Shurcliff, Brick House, Andover, Massachusetts.

[0003] Other examples of light valves are thin layers of liquid crystals in wrist watches and other displays, electrochromic coatings for automobile rear view mirrors which turn dark electronically, Kerr electro-optic cells for laser modulation, and photochromic glass for eyeglasses. Other light valves are discussed in "Electrochromic and Thermochronic Materials for Solar Energy Applications" USDOE Report LBL-18299.

[0004] Mechanical and electrical light valves suffer from cost and reliability problems. Mechanical and electrical light valves require both a separate sensor to determine which state of the light valve is desired, and a means for the sensor to activate the light valve.

[0005] For many applications, light valves should not become highly absorptive of light when they are in their non-transmissive state. For windows and skylights, for example, it is preferred that incident sunlight is reflected rather than absorbed so that it does not become a heat load for the building. Light absorption is a problem with the above mentioned photochromic glass, and photochromic, electrochromic, and thermochromic coatings, which all turn dark.

[0006] White paint for greenhouses is labor intensive and thus expensive. Since it is applied and removed seasonally, plant growth is slower than it would be with a light valve whose transmission varied over a time scale of minutes.

[0007] A light valve which turns from transmissive to reflective upon heating above its transition temperature and then turns transmissive again upon cooling is called here a "thermo-optical shutter." Since it is activated automatically by its local temperature, a thermo-optical shutter may be used without any external control mechanism in some applications, such as solar heating. For some other applications, such as skylights, it is preferred that the thermo-optical shutter be activated by ambient light intensity instead of local temperature.

[0008] Structures, preparation methods, and materials for thermo-optical shutters which are related to the present invention, and which are patented by the inventor, are given in U.S. Patents 3,953,110, 4,085,999 and 4,307,942.

[0009] Previous thermo-optical shutters related to the present invention have overcome the problems listed above for other types of light valves, but they have not performed as well as the present invention because: they do not retain their opacity for as long; or lack shear strength; or are difficult to manufacture; or are prone to puncture damage; or are prone to freezing damage; or are activated only by their local temperature, and not by local light intensity; or do not have a transition temperature which can be varied continuously over a range during the manufacture of the shutter. For example see US Patents Nos. US 4 832 366 and US 4 260 225.

SUMMARY OF THE INVENTION

[0010] The primary objects of this invention are a thermo-optical shutter with a structure enabling it to remain opaque for extended periods, which is simple and inexpensive to manufacture, and which is resistant to shear, creep, puncture and freezing. For some applications, a further object is a thermo-optical shutter which is activated by light intensity rather than temperature. A further object is a thermo-optical shutter whose transition temperature and light absorption can be varied continuously over a range during its manufacture. A further object is a thermo-optical shutter which reduces variations in incident light intensity. A further object is a visual display screen. Further objects will become apparent in the following text.

[0011] According to one aspect of the present invention, there is provided a layered structure having light reflectivity which is temperature-dependent, said structure comprising :

first and second cover layers, at least one of which is light transmissive; and an inner layer comprising a polymer and a solvent which form a homogeneous solution within a preselected temperature range and which separate into polymer-rich and solvent-rich phases outside said preselected temperature range, said polymer-rich and sol-

vent-rich phases together being substantially more reflective of light than said homogeneous solution; characterised in that said polymer comprises individual chains joined together with interchain bonds at points along their length and joined with interface bonds to said first and second cover layers to form a network of said bonds.

[0012] According to another aspect of the present invention, there is provided a method for forming a layered structure having light transmissivity which is temperature-dependent, said method comprising :

(a) joining together

(i) a first cover layer and a second cover layer, at least one of which is transparent; and
(ii) an inner layer comprising a polymer and a solvent which form a homogeneous solution within a preselected temperature range and which separate into polymer-rich and solvent-rich phases outside said preselected temperature range, said polymer-rich and solvent-rich phases together being substantially less transmissive of light than said homogeneous solution;

(b) joining individual chains of said polymer together with interchain bonds at points along their length; and
(c) forming interface bonds between a portion of said chains and said first and second cover layers.

[0013] According to another aspect of the present invention, there is provided a method for regulating solar energy transmission into a building, said method comprising :

(1) providing a layered structure having light reflectivity which is temperature-dependent, said structure comprising:

first and second cover layers (10), at least one of which is light transmissive; and
an inner layer comprising a polymer (11) and a solvent (12) which form a homogenous solution within a preselected temperature range and which separate into polymer-rich and solvent-rich phases outside said preselected temperature range, said polymer-rich and solvent-rich phases together being substantially more reflective of light than said homogenous solution;

said polymer (11) comprising individual chains joined together with interchain bonds (13) at points along their length and joined with interface bonds (14) to said first and second cover layers to form a network of said bonds, and said first second cover layers and said inner layer being substantially non-absorbing of light, and
(2) placing in the path of said solar energy-said layered structure.

[0014] According to a further aspect of the present invention, there is provided a display screen capable of forming an image on the screen from a temperature pattern on the screen, comprising a layered structure having light reflectivity which is temperature-dependent, said layered structure comprising:

first and second cover layers (10), at least one of which is light transmissive; and
an inner layer comprising a polymer (11) and a solvent (12) which form a homogenous solution within a preselected temperature range and which separate into polymer-rich and solvent-rich phases outside said preselected temperature range, said polymer-rich and solvent-rich phases together being substantially more reflective of light than said homogenous solution;
said polymer (11) comprised of individual chains joined together with interchain bonds (11) at points along their length and joined with interface bonds (14) to said first and second covered layers.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] Figure 1 shows a three-layered structure which may be used for a thermo-optical shutter.
[0016] Figure 2 shows a five-layered structure.
[0017] Figure 3 shows a typical production line for the above structures.
[0018] Figures 4A and 4B show a method for forming a grid of ultrasonic seals through the above structures.
[0019] Figure 5 shows the light transmission of a typical thermo-optical shutter with the above structure as a function of both temperature and incident light intensity.

DETAILED DESCRIPTION OF THE INVENTION AND PREFERRED EMBODIMENTS

Structure

[0020] A typical structure of this invention consists of a thermo-optical shutter layer sandwiched between two cover layers. These cover layers may be clear plastic films. The thermo-optical layer consists of a polymer and solvent, where the polymer precipitates reversibly from solution above its transition temperature, thereby reflecting light. More strictly speaking, the polymer and solvent form separate phases which are finely divided. One of the phases is solvent rich, which the other phase is polymer rich. In some cases the polymer rich phase is continuous, while in some other cases the solvent rich phase is continuous. The polymer and solvent layer is said to be in "solution" when the polymer chains are distributed fairly homogeneously throughout the solvent. This situation includes gels and plasticized polymers.

[0021] After the polymer and solvent layer has stayed above its transition temperature for long periods, such as several days, or after the polymer and solvent layer has been subjected to freezing and thawing, the polymer and solvent must remain finely divided for the polymer and solvent layer to be highly reflective. Pockets of either solvent or polymer should be prevented.

[0022] Also, its is desirable for the polymer and solvent layer to have some mechanical strength, to bond the two cover layers together, and to resist the creep and shear forces which may be externally applied to the sandwich structure during the installation and use. Both the ability to remain highly reflective for extended periods and the required mechanical strength can be imparted to the polymer and solvent layer by forming bonds both among the polymer chains and also between the polymer chains and both cover layers. Forming this network of bonds is here called "curing" the polymer and solvent layer.

[0023] In Figure 1, showing a fragmentary, sectional, schematic view of a typical three-layered sandwich structure, 10 are the cover layers, 11 is a polymer chain, 12 is the solvent for the polymer chains, 13 is a bond between two polymer chains, or an "interchain bond," 14 is a bond between a polymer chain and a cover layer, or an "interface bond," and 15 is a polymer chain which is not bonded.

[0024] In Figure 2, showing a fragmentary, sectional, schematic view of a typical five-layered sandwich structure, the parts are the same as in Figure 1, except that layers of an "interface bonder,", 21, are between the polymer chains and the cover layers, and 22 is a bond between a layer of interface bonder and a cover layer, and 23 is a bond between a layer of interface bonder and a polymer chain. The layer of interface bonder need not be continuous on a microscopic scale to be effective.

[0025] Stress may be generated within the middle layer of the sandwich structure when the polymer solution passes through its transition temperature or when the solvent freezes. The resultant phase separations change the conformation of the polymer chains, thereby stressing these chains and their interchain bonds and interface bonds. If stresses break these bonds, then pockets of separated polymer of solvent will form, thereby reducing the thermo-optical shutter's reflectivity and mechanical strength.

[0026] To resist internally and externally generated stressses, the molecular topology of the sandwich structure is such that stress can travel continuously from one cover layer, through bonds to the polymer chains, through bonds to the second cover layer. In examples 1, 2, and 3 to follow, the cover layers are connected to each other by a strong network of stable covalent bonds. These bonds go continuously from one cover layer to a layer of interface bonder to the layer of optical shutter polymer and solvent to another layer of interface bonder to the second cover layer, as is shown in Figure 2. This layered and bonded structure and the methods of manufacture necessitated by it are the core of this invention.

Manufacturing Methods

[0027] The polymer solution may be made with a viscosity from thixotropic to syrupy to suit the coating process employed, which may, for example, be cold extrusion, knife coating, or curtain coating. After coating onto the first cover layer, the polymer solution may then be covered with or laminated to the second cover layer. This may be done, for example, with a pair of rollers which are separated by a gap equal to the thickness of the finished product. These rollers simultaneously form the sandwich, meter the thickness of the polymer solution layer, and hold the top cover layer in place and under tension.

[0028] When heat may damage the sandwich, low heat curing should be used; for example, cure initiation by visible or ultraviolet light, or electron beam or curtain. Even these cure initiation methods involve some heat, so it is desirable to cool the uncured sandwich before or during curing with, for example, a chill drum, or cooled belt, or a moving fluid, such as cold air.

[0029] In Figure 3, showing a schematic of a typical method of manufacturing the sandwich structure, 31 are unwind stations for the rolls of cover layer film, 32 is uncured polymer solution, 33 is a knife over roll coating station which coats the uncured polymer solution onto the bottom cover layer, 34 is a nip roll station which both laminates the top

cover layer onto the uncured polymer solution and bottom cover layer, and which also meters the amount of uncured polymer solution between the two cover layers, 35 are rollers which cool the sandwich before and while it is being cured, 36 are radiation sources which cure the sandwich, and 37 is a windup station for the cured sandwich.

[0030] The manufacturing apparatus shown in Figure 3 is not unique and should not be construed as limiting this invention. For example, the knife over roll coater, 33, and the laminating rollers, 34, may be combined by eliminating 33. Or, the lower laminating roller, 34, may be cooled to eliminate the two cooling rollers, 35. Or, the two cooling rollers, 35, and the two radiation sources, 36, may be replaced by a single cooled roller and radiation source. Or, the coater roller, 33, and the lower laminating roller, 34, and the cooling rollers, 35, may all be replaced by a cooled belt. Or, some or all the rollers may be replaced with nonrotating bars or drums. Or, the top cover layer may be replaced with a release film, which, as a separate step on a different apparatus, is later removed and replaced with the top cover layer.

[0031] The cured sandwich should have enough shear strength to resist delamination from rough handling during installation and use. If the sandwich is punctured, it is desirable that the loss of solvent from the inner layer be confined to the local area of the puncture, so that the entire sheet of sandwich does not cease to function. Both shear strength and puncture resistance can be imparted to the sandwich by forming a grid of seals between the cover layers, where the weaker inner layer has been removed from the area of the seal. The grid of seals may be square, hexagonal, etc. For some applications, the seals should be as thin as possible to reduce light transmission through the seals when the thermo-optical shutter is in its reflective state.

[0032] The seals may be made either on the same production line as the sandwich or on a separate production line. For example, two methods of forming the seal grid are heat sealing and ultrasonic welding. The weak inner layer of the sandwich may be removed from the seal area by pressure from the sealing element. With heat sealing, this pressure may be reduced before the cover layers melt to prevent excessive thinning of the cover layers at the seal. A laminated cover may be used with a higher melting polymer on the outside of the sandwich.

[0033] For ultrasonic sealing as a continuous web process, it is useful to have a drum with the seal pattern in raised ribs on its surface. This drum rotates with the web to carry it under the stationary ultrasonic horn or horns, where first the polymer and solvent layer is squeezed away from the area of the sale and then the seal is made in a single pass.

[0034] In Figures 4A and 4B, showing a schematic of a typical manufacturing method for making ultrasonic seals between the cover layers, 41, is a roller, 42 is a grid of raised ribs which forms the seals, 43 is an ultrasonic horn, 44 is an unsealed sandwich of cover layers and a polymer and solvent layer, 45 are the cover layers, 46 is the polymer and solvent layer, and 47 is a seal between the cover layers.

[0035] For ease of manufacture, it is desirable that the polymer solution layer have a high viscosity when the sandwich is formed. This permits easy formation of a sandwich with uniform thickness. Also it is desirable for the sandwich curing to create as little heat as possible, since it has been found that if the polymer and solvent layer is cured while above its transition temperature, the sharpness of the transition temperature is reduced.

[0036] The high viscosity of the uncured polymer solution, and the low heat of curing can both be effected by using a solution of the polymer, with the polymer's degree of polymerization above ten, rather than forming the sandwich directly from a monomer solution. In curing, these polymer chains are subsequently bonded to each other. The bonds may, for example, be chemical, van der Walls or electrostatic; although hydrolytically stable covalent bonds are preferred with water solvents.

[0037] For the sandwich structure to cure, it is necessary to have bonding sites on both the polymer chains and the inner surfaces of the cover layers. The bonding sites on the polymer chains may consist of, for example, unsaturation or other functionality, or sites made during the cure by a "bond site maker" which is in the uncured polymer solution. The bonding sites on the cover layers may consist of, for example, functionality made by vacuum or atmospheric plasma pretreatment, or sites made during cure by a bond site maker.

[0038] The bonding sites on the polymer chains may be bonded to each other during cure either directly or by an "interchain bonder" which is in the uncured polymer solution. The bonding sites on the cover layers may bond either directly to the bonding sites on the polymer chains or they may bond to an intermediate layer of "interface bonder", which bonds, in turn, to the bonding sites on the polymer chains. This interface bonder is in the uncured polymer solution, but it should have lower solubility than the interchain bonder because it must form at least partial monolayers between the cover layers and the polymer solution.

[0039] Another method of curing the sandwich structure is to cold extrude a thixotropic polymer solution between two cover layers, and then allow the polymer to cure slowly over time, for example, with the sandwich stored in rolls. In this case the curing of both the polymer in solution and the cover layer inner surfaces may be activated, for example, by mixing the polymer solution from two reactive components before extrusion.

[0040] The polymer solution components may also react quickly. In this case, the mixing and the forming of the polymer layer must be done in rapid succession; using, for example, a mixer combined with extruder similar to those used for forming urethane coatings commercially. With rapid cure, the components need not be highly thixiotropic.

[0041] In order to adjust the transition temperature precisely over a range for various applications, it is useful to make the polymer from two or more monomers which, when polymerized alone, would make polymers with different transition

temperatures. The transition temperature of the copolymer will then be a function of the monomer ratios. It has been found that the copolymerization should be somewhat random so that the transition temperature is both sharper and less sensitive to solvent concentration. For example, block copolymers are much less satisfactory than random copolymers in both of the above properties.

Operation

[0042] There are applications for thermo-optical shutters where a constant level of transmitted light is desired, even though incident light levels are varying. These applications include daylight illumination sources such as skylight. This effect can be achieved by adding a small amount of an inert dye, such as carbon black, to the polymer solution. Alternately, a cover layer with light absorption may be used. The resulting absorption causes the thermo-optical shutter to be heated by the incident light and turn reflective.

[0043] In Figure 5, showing a typical set of graphs of direct plus diffuse light transmission of the thermo-optical shutter as a function of both temperature and incident light intensity, 51 is the transmission at low light intensity, 52 is the transmission at medium light intensity, and 53 is the transmission at high light density.

[0044] For a given illumination source configuration and orientation, a unique amount of light absorption exists such that the transmitted light is most nearly constant, even though incident light levels may vary over a wide range. Similarly, for a given configuration, orientation, and ambient thermal regime, a unique transition temperature exists such that the transmitted light is most nearly constant.

[0045] The invariance of the transmitted light intensity may be further enhanced by having the light absorption take place primarily after the thermo-optical shutter layer. With this structure, the absorber is shaded by the shutter when it is in its reflective state. For the following applications, the definition of a thermo-optical shutter is expanded to include the case where the shutter turns reflective on cooling rather than heating, as it did in the previous applications.

[0046] A thermo-optical shutter may be used to make a visual display which may be either transparent or opaque when there is no image on the screen. For example, the shutter may form a screen which is scanned in a raster pattern by a thin beam of invisible infrared light, which is analogous to the electron beam in a TV tube. The infrared light is absorbed by an element of the shutter and heats it above its transition temperature which switches its state of reflectivity. Thus the pattern of reflectivity on the shutter screen is controlled by modulating the intensity of the infrared beam as it scans. Alternately, a shutter element may be heated electrically by a grid of resistive elements on one of the cover layers. The grid may be of the coincident circuit type, and the resistive elements may be transparent.

[0047] A thermo-optical shutter may be used to form a hologram which is variable in time. The hologram is written with a wavelength of coherent light that is absorbed by the shutter and thereby heats it. It is read with wavelengths that are not absorbed. Because it is a hologram, the read and write wavelengths should be harmonics for good performance. The thickness of the shutter may be many times a wavelength of light, so the shutter may form a three-dimensional hologram.

[0048] This variable hologram may be used to form a three-dimensional display, preferably by reading it with coherent light. Alternately, it may be used for optical information processing. For example, since a thermo-optical shutter which has some absorption and which is near its transition temperature is a highly non-linear optical medium, as is shown in Figure 5, it may be used to form a phase conjugation mirror. This mirror may be used for optical pattern recognition, for example,

Test Methods and Apparatus

[0049] The performance of the bonding of the sandwich is measured in two ways. In the first test, a sample sandwich is immersed in hot water for one hour and then immersed in water which is 30°C below its transition temperature. If separation between a cover layer and the cured polymer and solvent layer has occurred, the interface has a surface appearance similar to orange peel. The temperature of the hot water is raised in 5°C steps until separation occurs. If a temperature of 30°C above the transition temperature has been reached, the interface bonding is satisfactory.

[0050] The second test measures bonding by immersing a sample sandwich with one cover film carefully peeled off in solvent which is 30°C below the transition temperature. The solvent used is the same as the solvent in the sandwich. On immersion the cured polymer solution layer expands due to the uptake of solvent, which puts both interchain and interface bonds under strain. If no separation of the polymer solution layer from the cover layer occurs within 48 hours, both the interface bonding and the interchain bonding are satisfactory.

[0051] Passing both of the above bonding tests shows that the sandwich has a bonded structure.

[0052] The apparatus for measuring direct plus diffuse light transmission versus temperature, as shown in Figure 5, consists of light bulb and photoelectric cell detector spaced a centimeter apart and immersed in a stirred water bath. The bath temperature is controlled with a hot plate and a cooling coil. The signals from the photoelectric cell and a thermistor in the bath to an X-Y recorder, which gives a plot of light transmission versus temperature. A sharpness in

transition temperature of 5°C or less is satisfactory.

[0053] To measure the sensitivity of the transition temperature to the concentration of the polymer in the solvent, one cover layer is carefully peeled off a sample sandwich. The sample is then partially dried and weighed to determine the new polymer concentration. The cover layer is replaced, the sandwich edges are resealed, and a new transmission versus temperature curve is measured. When the polymer concentration has changed from 30% to 60%, a change in transition temperature of 5°C or less is satisfactory.

EXAMPLE 1

[0054] A thermo-optical shutter polymer solution which is highly viscous may consist of polyvinylmethyl ether in water. This solution is made capable of curing, or bonding to both itself and the cover layers, by mixing in the following bonding additives:

Polymer Solution (30% polyvinylmethyl ether, GAF)	100 g
Bond Site Maker (hydrogen peroxide)	0.15 g
Interchain Bonder (methylene bisacrylamide, Aldrich)	1.5 g
Interface Bonder (divinyl spirodioxane, Aldrich)	0.15 g
photoinitiator (methyl phenylglyoxylate, Aldrich)	0.5 g

[0055] The optical shutter sandwich structure may be prepared by the following process: on a clean piece of cover layer, for example a clear film of polyvinylacetate or polypropylene, is placed a spacer frame three millimeters in thickness and enclosing an area of five by three centimeters. Some polymer solution, with the bonding additives mixed in, is placed in the area inside the space framer and a second piece of cover layer is placed over the spacer. This sandwich assembly is then pressed between two flat surfaces to form a layer of polymer solution of uniform thickness which fills the volume enclosed by the spacer framer and the cover layers.

[0056] Curing is initiated by ultraviolet light from a mercury lamp one meter from the sample. The above sandwich is placed on a metal tray which is resting on ice for cooling. The sandwich is irradiated one hour on each side to cure it. The spacer is then removed and the sandwich edges are sealed by ultrasonic welding the two polymer cover films together through the cured polymer and solvent layer.

[0057] Sandwich structures prepared with the above methods pass all the above performance tests for bonding, transition temperature sharpness, and insensitivity to solvent concentration.

EXAMPLE 2

[0058] The sandwich structure, its preparation, and its performance are identical to Example 1 except that the polymer is replaced by a random copolymer, which is prepared from the following ingredients:

Monomer 1 (N-isopropyl acrylamide, Eastman Kodak)	94 g
Monomer 2 (acrylamide, Aldrich)	6 g
Solvent (water)	400 g
catalyst (1% potassium bisulphite, plus 1% potassium persulphate, in water)	1 g

[0059] The monomers are dissolved in the solvent in a stirred reactor and the catalyst is added. The reactor is kept at 30°C for 24 hours to complete the copolymerization. The copolymer solution is heated to 70°C, which causes the copolymer to coagulate, and sufficient solvent is removed to bring the remaining solution to 30% concentration. The mixture is then cooled and stirred until homogeneous.

[0060] By replacing the polymer of Example 1 with another polymer and still passing all of the above performance tests, this example shows that this invention, whose subject is a layered and bonded structure, is independent of the particular materials used to make that structure. Some of these materials are the subject of a copending application.

EXAMPLE 3

[0061] The sandwich structure, its preparation, and its performance are identical to Example 2 except that the random copolymer has a different ratio between monomer 1 and monomer 2 and thus a different transition temperature. For example, when the amount of monomer 2 is changed from 6% to 14% of the copolymer, the transition temperature changes from 35°C to 45°C.

[0062] This example shows that the transition temperature can be varied over a range without loosing any performance properties.

EXAMPLES 4 THROUGH 7

[0063] The sandwich structures and their preparation are identical to Example 3 except that the bonding additives (i.e., bond site maker, interchain bonder, interface bonder, and photoinitiator) are each reduced, one at a time, to half the quantities listed in Example 1, while keeping all the other additives constant. The resulting four samples all fail one or both of the above bonding tests.

[0064] These examples show that although the quantities of bonding additives are minute, each plays an essential role.

Claims

1. A layered structure having light reflectivity which is temperature-dependent, said structure comprising :

   first and second cover layers (10), at least one of which is light transmissive; and an inner layer comprising a polymer (11) and a solvent (12) which form a homogenous solution within a preselected temperature range and which separate into polymer-rich and solvent-rich phases outside said preselected temperature range, said polymer-rich and solvent-rich phases together being substantially more reflective of light than said homogenous solution;

   characterised in that said polymer (11) comprises individual chains joined together with interchain bonds (13) at points along their length and joined with interface bonds (14) to said first and second cover layers (10) to form a network of said bonds.

2. A layered structure in accordance with claim 1, wherein said polymer chains are joined with interface bonds (14) to said first cover layer (10) through a substantially transparent intermediate interface bonder layer (21) positioned between said first cover layer (10) and said inner layer.

3. A layered structure in accordance with claim 1, wherein said polymer chains are joined with said interface bonds (14) to said first and second cover layers (10) through substantially transparent first and second intermediate interface bonder layers (21) positioned between said first cover layer (10) and said inner layer and between said inner layer and said second cover layer (10), respectively.

4. A layered structure in accordance with claim 1, 2 or 3, wherein said interface and interchain bonds (13, 14) are chemical bonds.

5. A layered structure in accordance with claims 1, 2 or 3, wherein said interface and interchain bonds (13, 14) are primarily covalent and are stable with respect to said solvent.

6. A layered structure in accordance with claim 1, wherein a portion of said polymer (11) is a copolymer of at least two monomers, and said preselected temperature range is bounded by a transition temperature whose value varies with the relative amounts of said monomers.

7. A layered structure in accordance with claim 6, wherein a portion of said polymer (11) is a random copolymer of at least two monomers, and said preselected temperature range is bounded by a transition temperature whose value varies with the relative amounts of said monomers.

8. A layered structure in accordance with claim 1, 2 or 3, being partially absorptive of sun light such that heat generated by absorbed light increases said light reflectivity of the structure.

9. A layered structure in accordance with claim 1, wherein the inner layer provides a thermo-optical layer between the first and second cover layers (10), said structure being partially absorptive of incident light such that heat generated by absorbed incident light increases said reflectivity, wherein the light absorption occurs primarily after said incident light passes through said thermo-optical layer in the direction of travel of the incident light.

10. A layered structure in accordance with claim 9, wherein said temperature dependence and the degree to which said structure is partially absorptive of incident light are selected such that said structure reduces variations in transmitted light intensity when incident light intensity and ambient temperature are within a preselected range such that transmitted light is regulated to provide more constant intensity of illumination.

11. A layered structure in accordance with claim 1, wherein first and second cover layers (10) are sealed together by ultrasonic vibrations.

12. A layered structure in accordance with claim 11, wherein said first and second cover layers (10) are sealed together by passing said inner and first and second cover layers (10) over a drum (41) bearing raised ribs (42) in a grid pattern along the surface thereof and rotating under an ultrasonic horn (43).

13. A layered structure in accordance with claim 11, wherein said first and second cover layers (10) are sealed together by heat.

14. A layered structure in accordance with claim 1, wherein said polymer (11) is formed from preformed polymer chains which are then formed together with bonds.

15. A structure in accordance with claim 1, 2 or 3, wherein at least a portion of said bonds (13, 14) are initiated by radiation.

16. A structure in accordance with claim 15 in which at least a portion of said bonds (13, 14) are initiated by ultraviolet radiation.

17. A structure in accordance with claim 15 in which at least a portion of said bonds (13, 14) are initiated by visible light.

18. A structure in accordance with claim 15 in which at least a portion of said bonds (13, 14) are initiated by electron radiation.

19. A structure in accordance with claim 1, 2 or 3 made by mixing a polymer and/or monomer solution with components which react to form the interface or interchain bonds (13, 14).

20. A structure in accordance with claim 1, 2 or 3, including means for forming the interchain and interface bonds including one or more of :
functionality on the polymer chains, functionality on a cover layer inner surface, a bond site maker, an interchain bonder, an interface bonder.

21. A structure in accordance with claim 1, 2 or 3 including means to cool the structure while the bonds (13, 14) are being formed.

22. A structure in accordance with claim 19 wherein said monomer is divinyl spiro dioxane.

23. A method for forming a layered structure having light transmissivity which is temperature-dependent, said method comprising :

(a) joining together

(i) a first cover layer (10) and a second cover layer (10), at least one of which is transparent; and
(ii) an inner layer comprising a polymer (11)and a solvent (12) which form a homogenous solution within a preselected temperature range and which separate into polymer-rich and solvent-rich phases outside said preselected temperature range, said polymer-rich and solvent-rich phases together being substantially less transmissive of light than said homogenous solution;

(b) joining individual chains of said polymer together with interchain bonds (13) at points along their length; and
(c) forming interface bonds (14) between a portion of said chains and said first and second cover layers (10).

24. A method in accordance with claim 23 in which step (c) comprises forming said interface bonds (14) between a portion of said chains and said first cover layer (10) through an intermediate layer (21).

25. A method in accordance with claim 23 in which step (c) comprises forming said interface bonds (14) between a portion of said chains and said first and second cover layers (10) through first and second intermediate interface bonder layers (21), respectively.

26. A method for forming a layered structure in accordance with claim 23, 24 or 25 in which said first cover layer (10) and said second cover layer (10) are placed spaced apart by a fixed gap thereby defining the thickness of said inner layer.

27. A method for forming a layered structure in accordance with claim 23 in which said first cover layer (10) and said second cover layer (10) are placed spaced apart by a fixed gap formed by two parallel cylinders (34) thereby defining the thickness of said inner layer.

28. A method for forming a layered structure in accordance with claim 26 in which said first cover layer (10) and said second cover layer (10) are placed spaced apart by a fixed gap formed by the extrudate of an extrusion die thereby defining the thickness of said inner layer.

29. A method for forming a layered structure in accordance with claim 26 in which said first cover layer (100 and said second cover layer (10) are placed spaced apart by a fixed gap formed by an inner layer formed by a knife over roll coater (33) thereby defining the thickness of said inner layer.

30. A method for regulating solar energy transmission into a building, said method comprising :

(1) providing a layered structure having light reflectivity which is temperature-dependent, said structure comprising:

first and second cover layers (10), at least one of which is light transmissive; and
an inner layer comprising a polymer (11) and a solvent (12) which form a homogenous solution within a preselected temperature range and which separate into polymer-rich and solvent-rich phases outside said preselected temperature range, said polymer-rich and solvent-rich phases together being substantially more reflective of light than said homogenous solution;

said polymer (11) comprising individual chains joined together with interchain bonds (13) at points along their length and joined with interface bonds (14) to said first and second cover layers to form a network of said bonds, and said first second cover layers and said inner layer being substantially non-absorbing of light, and
(2) placing in the path of said solar energy said layered structure.

31. A display screen capable of forming an image on the screen from a temperature pattern on the screen, comprising a layered structure having light reflectivity which is temperature-dependent, said layered structure comprising:

first and second cover layers (10), at least one of which is light transmissive; and
an inner layer comprising a polymer (11) and a solvent (12) which form a homogenous solution within a preselected temperature range and which separate into polymer-rich and solvent-rich phases outside said preselected temperature range, said polymer-rich and solvent-rich phases together being substantially more reflective of light than said homogenous solution;
said polymer (11) comprised of individual chains joined together with interchain bonds (11) at points along their length and joined with interface bonds (14) to said first and second covered layers.

Patentansprüche

1. Schichtstruktur mit temperaturabhängiger Lichtreflexion, umfassend eine erste und eine zweite Deckschicht (10), wovon mindestens eine lichtdurchlässig ist; eine Innenschicht, welche ein Polymer (11) und ein Lösungsmittel (12) aufweist, die innerhalb eines vorgewählten Temperaturbereichs eine homogene Lösung bilden und die sich außerhalb des gewählten Temperaturbereichs in eine polymerreiche und eine lösungsmittelreiche Phase trennen, wobei die polymerreiche und die lösungsmittelreiche Phasen zusammen sehr viel stärker lichtreflektierend sind als die homogene Lösung;
dadurch gekennzeichnet, dass das Polymer (11) einzelne Ketten aufweist, die an Stellen über ihre Länge durch Interketten-Verknüpfungen (13) miteinander verbunden sind und die durch Interflächen-Verknüpfungen (14)

mit der ersten und der zweiten Deckschicht (10) verbunden sind, so dass ein Netz von Bindungen vorliegt.

2. Schichtstruktur nach Anspruch 1, wobei die Polymerketten durch Interflächen-Verknüfungen (14) über eine im Wesentlichen transparente Interflächen-Binderzwischenschicht (21), die zwischen der ersten Deckschicht (10) und der Innenschicht liegt, mit der ersten Deckschicht (10) verbunden sind.

3. Schichtstruktur nach Anspruch 1, wobei die Polymerketten durch Interflächen-Verknüpfungen (14) über im Wesentlichen transparente erste und zweite Interflächen-Binderzwischenschichten (21), die zwischen der ersten Deckschicht (10) und der Innenschicht beziehungsweise zwischen der Innenschicht und der zweiten Deckschicht (10) liegen, mit der ersten und der zweiten Deckschicht (10) verbunden sind.

4. Schichtstruktur nach Anspruch 1, 2 oder 3, wobei die Interflächen- und die Interketten-Verknüpfungen (13, 14) chemische Bindungen sind.

5. Schichtstruktur nach Anspruch 1, 2 oder 3, wobei die Interflächen- und die Interketten-Verknüpfungen (13, 14) in erster Linie kovalent und gegenüber dem Lösungsmittel stabil sind.

6. Schichtstruktur nach Anspruch 1, wobei ein Teil des Polymers (11) ein Copolymer von mindestens zwei Monomeren ist und der vorgewählte Temperaturbereich von der Übergangstemperatur begrenzt wird, deren Wert sich mit den relativen Mengen der Monomere ändert.

7. Schichtstruktur nach Anspruch 6, wobei ein Teil des Polymers (11) ein Random-Copolymer aus mindestens zwei Monomeren ist und der vorgewählte Temperaturbereich von der Übergangstemperatur begrenzt wird, deren Wert sich mit den relativen Mengen der Monomere ändert.

8. Schichtstruktur nach Anspruch 1, 2 oder 3, die teilweise das Sonnenlicht derart absorbiert, dass die vom absorbierten Licht erzeugte Wärme die Lichtreflexion der Struktur erhöht.

9. Schichtstruktur nach Anspruch 1, wobei die Innenschicht zwischen der ersten und der zweiten Deckschicht (10) eine thermooptische Schicht bildet, deren Struktur für einfallendes Licht so partiell absorbierend ist, dass die vom absorbierten einfallenden Licht erzeugte Wärme die Reflexion erhöht, wobei die Lichtabsorption hauptsächlich erfolgt, nachdem das einfallende Licht in Laufrichtung durch die thermooptische Schicht hindurchgegangen ist.

10. Schichtstruktur nach Anspruch 9, wobei die Temperaturabhängigkeit und der Grad der partiellen Absorption der Struktur für einfallendes Licht derart gewählt sind, liegen die Intensität des einfallenden Lichts und die Umgebungstemperatur innerhalb eines vorgewählten Bereichs, dass die Struktur die Intensitätsschwankungen des durchgelassenen Lichts vermindert, das durchgelassene Licht regelt und eine konstante Beleuchtungsintensität bereitstellt.

11. Schichtstruktur nach Anspruch 1, wobei die erste und die zweite Deckschicht (10) durch Ultraschallschwingungen miteinander versiegelt sind.

12. Schichtstruktur nach Anspruch 11, wobei die erste und die zweite Deckschicht (10) miteinander versiegelt sind durch Schicken der Innen- sowie der ersten und der zweiten Deckschicht (10) über eine Trommel (41), die längs auf ihrer Oberfläche in einem Gittermuster erhabene Rippen (42) besitzt und Drehen unter einem Ultraschalltrichter (43).

13. Schichtstruktur nach Anspruch 11, wobei die erste und die zweite Deckschicht (10) durch Wärme miteinander versiegelt sind.

14. Schichtstruktur nach Anspruch 1, wobei das Polymer (11) aus vorgebildeten Polymerketten hergestellt ist, das dann zusammen mit den Verknüpfungen gebildet wird.

15. Struktur nach Anspruch 1,2 oder 3, wobei mindestens ein Teil der Verknüpfungen (13, 14) durch Strahlen erzeugt werden.

16. Struktur nach Anspruch 15, in der mindestens ein Teil der Verknüpfungen (13, 14) durch ultraviolette Strahlen erzeugt werden.

17. Struktur nach Anspruch 15, in der mindestens ein Teil der Verknüpfungen (13, 14) durch sichtbares Licht erzeugt werden.

18. Struktur nach Anspruch 15, in der mindestens ein Teil der Verknüpfungen (13, 14) durch Elektronenstrahlen erzeugt werden.

19. Struktur nach Anspruch 1, 2 oder 3, hergestellt durch Mischen eines Polymer- und/oder einer Monomer-Lösung mit Komponenten, die sich unter Bildung von Interflächen- oder der Interketten-Verbindungen (13, 14) umsetzen.

20. Struktur nach Anspruch 1, 2 oder 3, beinhaltend Mittel zum Ausbilden der Interketten- und der Interflächen-Verknüpfungen, die ein oder mehrere von Folgendem aufweisen: Funktionalitäten auf den Polymerketten; Funktionalitäten auf der Deckschicht-Innenfläche, Verknüpfungsstellenmacher, Interkettenverknüpfer, Interflächenverknüpfer.

21. Struktur nach Anspruch 1, 2 oder 3, beinhaltend Mittel zum Kühlen der Struktur während die Verknüpfungen (13, 14) gebildet werden.

22. Struktur nach Anspruch 19, wobei das Monomer Divinylspiro-dioxan ist.

23. Verfahren zur Herstellung einer Schichtstruktur mit temperaturabhängiger Lichtdurchlässigkeit, umfassend

(a) miteinander Verbinden von

(i) einer ersten Deckschicht (10) und einer zweiten Deckschicht (10), wovon mindestens eine transparent ist; und
(ii) einer Innenschicht, welche ein Polymer (11) und ein Lösungsmittel (12) aufweist, die innerhalb eines vorgegebenen Temperaturbereichs eine homogene Lösung bilden und die außerhalb des vorgegebenen Temperaturbereichs sich in eine polymerreiche und eine lösungsmittelreiche Phase trennen, wobei die polymerreiche und die lösungsmittelreiche Phase zusammen erheblich weniger lichtdurchlässig sind als die homogene Lösung;

(b) Verbinden einzelner Ketten des Polymers miteinander an Stellen über deren Länge durch Interketten-Verknüpfungen (13); und
(c) Ausbilden von Interflächen-Verknüpfungen (14) zwischen einem Teil der Ketten und der ersten und der zweiten Deckschicht (10).

24. Verfahren nach Anspruch 23, wobei der Schritt (c) umfasst das Ausbilden der Interflächen-Verknüpfungen (14) zwischen einem Teil der Ketten und der ersten Deckschicht (10) über eine Zwischenschicht (21).

25. Verfahren nach Anspruch 23, in dem der Schritt (c) umfasst das Ausbilden von Interflächen-Verknüpfungen (14) zwischen einem Teil der Ketten und der ersten und der zweiten Deckschicht (10) über eine erste beziehungsweise eine zweite Interflächen-Binderzwischenschicht (21).

26. Verfahren zum Ausbilden einer Schichtstruktur gemäß Anspruch 23, 24 oder 25, wobei die erste Deckschicht (10) und die zweite Deckschicht (10) durch einen festen Spalt voneinander beabstandet werden, der die Dicke der Innenschicht bestimmt.

27. Verfahren zum Ausbilden einer Schichtstruktur gemäß Anspruch 23, wobei die erste Deckschicht (10) und die zweite Deckschicht (10) voneinander beabstandet werden durch einen festen Spalt, der durch zwei parallele Zylinder (34) hergestellt wird und der die Dicke der Innenschicht bestimmt.

28. Verfahren zur Ausbildung einer Schichtstruktur gemäß Anspruch 26, wobei die erste Deckschicht (10) und die zweite Deckschicht (10) voneinander beabstandet werden durch einen festen Spalt, der durch das Extrudat einer Extruderform hergestellt wird und der die Dicke der Innenschicht bestimmt.

29. Verfahren zur Ausbildung einer Schichtstruktur gemäß Anspruch 27, wobei die erste Deckschicht (10) und die zweite Deckschicht (10) voneinander beabstandet werden durch einen festen Spalt, der von der Innenschicht gebildet wird, die mithilfe eines Messers über einer Beschichterwalze (33) hergestellt wird, und der die Dicke der

Innenschicht bestimmt.

30. Verfahren zur Regelung der Durchlässigkeit für Solarenergie in einem Gebäude, umfassend

(1) Bereitstellen einer Schichtstruktur mit temperaturabhängiger Lichtreflexion, umfassend

eine erste und eine zweite Deckschicht (10), wovon mindestens eine lichtdurchlässig ist, und eine Innenschicht, welche ein Polymer (11) und ein Lösungsmittel (12) enthält, die innerhalb eines vorgewählten Temperaturbereichs eine homogene Lösung bilden und die sich außerhalb des gewählten Temperaturbereichs in eine polymerreiche und eine lösungsmittelreiche Phase trennen, wobei die polymerreiche und die lösungsmittelreiche Phase zusammen erheblich stärker lichtreflektierend sind als die homogene Lösung;
wobei das Polymer (11) einzelne Ketten besitzt, die an Stellen über ihre Länge durch Interketten-Verknüpfungen (13) miteinander verbunden sind und die durch Interflächen-Verknüpfungen (14) mit der ersten und der zweiten Deckschicht verbunden sind, so dass ein Netz von Verknüpfungen vorliegt, wobei die erste und die zweite Deckschicht und die Innenschicht Licht im Wesentlichen nicht absorbieren, und

(2) Anordnen der Schichtstruktur in den Weg der Solarenergie.

31. Anzeigefeld, das aus dem Feld-Temperaturmuster eine Abbildung auf dem Feld darstellen kann, enthaltend eine Schichtstruktur mit temperaturabhängiger Lichtreflexion, umfassend

eine erste und eine zweite Deckschicht (10), wovon mindestens eine lichtdurchlässig ist; und eine Innenschicht mit einem Polymer (11) und einem Lösungsmittel (12), die in einem vorgegebenen Temperaturbereich eine homogene Lösung bilden und die sich außerhalb des vorgegebenen Temperaturbereichs in eine polymerreiche und eine lösungsmittelreiche Phase trennen, wobei die polymerreiche und die lösungsmittelreiche Phase zusammen sehr viel stärker lichtreflektierend sind als die homogene Lösung,
wobei das Polymer (11) einzelne Ketten enthält, die an Stellen über ihre Länge durch Interketten-Verknüpfungen (11) miteinander verbunden sind und die durch Interflächen-Verknüpfungen (14) mit der ersten und der zweiten Deckschicht verbunden sind.

Revendications

1. Une structure en couches présentant un pouvoir de réflexion de la lumière qui dépend de la température, ladite structure comprenant :

de première et seconde couches de recouvrement (10), dont au moins une transmet la lumière ; et une couche interne comprenant un polymère (11) et un solvant (12) qui forment une solution homogène dans une gamme de températures sélectionnée au préalable et qui se séparent en phases riche en polymère et riche en solvant à l'extérieur de ladite gamme de températures sélectionnée au préalable, lesdites phases riche en polymère et riche en solvant étant ensemble sensiblement davantage réfléchissantes de la lumière qui ladite solution homogène ;

caractérisé en ce que ledit polymère (11) comprend des chaînes individuelles réunies entre elles par des liaisons interchaînes (13) au niveau de points sur leur longueur et réunies par des liaison interfaces (14) auxdites première et seconde couches de recouvrement (10) pour former un réseau desdites liaisons.

2. Une structure en couches selon la revendication 1, dans laquelle les chaînes dudit polymère sont réunies par des liaisons interfaces (14) à ladite première couche de recouvrement (10) via une couche de liaison interface intermédiaire sensiblement transparente (21) mise en place entre ladite première couche de recouvrement (10) et ladite couche interne.

3. Une structure en couches selon la revendication 1, dans laquelle les chaînes dudit polymère sont réunies par les dites liaisons interfaces (14) auxdites première et seconde couches de recouvrement (10) via de première et seconde couches de liaison interfaces intermédiaires sensiblement transparentes (21) mises en place entre ladite première couche de recouvrement (10) et ladite couche interne et, respectivement, entre ladite couche interne et ladite seconde couche de recouvrement (10).

4. Une structure en couches selon la revendication 1, 2 ou 3, dans laquelle lesdites liaisons interfaces et interchaînes (13, 14) sont des liaisons chimiques.

5. Une structure en couches selon les revendications 1, 2 ou 3, dans laquelle lesdites liaisons interfaces et interchaînes (13, 14) sont principalement covalentes et sont stables par rapport audit solvant.

6. Une structure en couches selon la revendication 1, dans laquelle une partie dudit polymère (11) est un copolymère d'au moins deux monomères, et ladite gamme de températures sélectionnée au préalable est limitée par une température de transition dont la valeur varie avec les quantités relatives desdits monomères.

7. Une structure en couches selon la revendication 6, dans laquelle une partie dudit polymère (11) est un copolymère aléatoire d'au moins deux monomères, et dans laquelle ladite gamme de températures sélectionnée au préalable est limitée par une température de transition dont la valeur varie avec les quantités relatives desdits monomères.

8. Une structure en couches selon la revendication 1, 2 ou 3, qui est partiellement absorbante de la lumière du soleil de telle manière que la chaleur produite par la lumière absorbée augmente ledit pouvoir de réflexion de la lumière de la structure.

9. Une structure en couches selon la revendication 1, dans laquelle la couche interne crée une couche thermo-optique entre lesdites première et seconde couches de recouvrement (10), ladite structure étant partiellement absorbante de la lumière incidente de telle manière que la chaleur produite par la lumière incidente absorbée augmente ledit pouvoir de réflexion, et dans laquelle l'absorption de lumière se produit principalement après que ladite lumière incidente passe à travers ladite couche thermo-optique dans la direction de déplacement de la lumière incidence.

10. Une structure en couches selon la revendication 9, dans laquelle ladite dépendance de la température et le degré auquel ladite structure est partiellement absorbante de la lumière incidente sont sélectionnées de telle manière que ladite structure réduit les variations dans l'intensité de la lumière transmise lorsque l'intensité de la lumière incidente et la température ambiante sont dans une gamme sélectionnée au préalable telle que la lumière transmise est régulée pour fournir une intensité d'éclairage davantage constante.

11. Une structure en couches selon la revendication 1, dans laquelle les première et seconde couches de recouvrement (10) sont scellées entre elles par des ultrasons.

12. Une structure en couches selon la revendication 11, dans laquelle lesdites première et seconde couches de recouvrement (10) sont scellées entre elles par passage de ladite couche interne et desdites première et seconde couches de recouvrement (10) sur un tambour (41) portant des nervures en relief (42) disposées en un motif de grille le long de sa surface et tournant sous un cornet à ultrasons (43).

13. Une structure en couches selon la revendication (11), dans laquelle lesdites première et seconde couches de recouvrement (10) sont scellées entre elles par de la chaleur.

14. Une structure en couches selon la revendication 1, dans laquelle ledit polymère (11) est formé à partir de chaînes de polymères préformées qui sont ensuite formées ensemble par des liaisons.

15. Une structure selon la revendication 1, 2 ou 3, dans laquelle au moins une partie desdites liaisons (13, 14) est amorcée par un rayonnement.

16. Une structure selon la revendication 15, dans laquelle au moins une partie desdites liaisons (13, 14) est amorcée par un rayonnement ultraviolet.

17. Une structure selon la revendication 15, dans laquelle au moins une partie desdites liaisons (13, 14) est amorçée par de la lumière visible.

18. Une structure selon la revendication 15, dans laquelle au moins une partie desdites liaison (13, 14) est amorçée par un rayonnement électronique.

19. Une structure selon la revendication 1, 2 ou 3 réalisée par mélange d'une solution de polymère et ou de monomère

avec des composés qui réagissent pour former les liaisons interfaces ou interchaînes (13, 14).

20. Une structure selon la revendication 1, 2 ou 3, comprenant des moyens pour former les liaisons interchaînes et interfaces qui comprenent un ou plusieurs des éléments suivants:

fonctionnalité sur les chaînes de polymères, fonctionnalité sur une surface interne de la couche de recouvrement, un fabriquant de site de liaison, un organe de liaison interchaîne, un organe de liaison interface.

21. Une structure selon la revendication 1, 2 ou 3, comprenant des moyens pour refroidir la structure alors que les liaisons (13, 14) sont en cours de formation.

22. Une structure selon la revendication 19, dans laquelle ledit monomère est du divinyl spiro-dioxane.

23. Un procédé de formation d'une structure en couches présentant un pouvoir de transmission de la lumière qui dépend de la température, ledit procédé comprenant les étapes consistant à :

(a) réunir entre elles

(i) une première couche de recouvrement (10) et une seconde couche de recouvrement (10), dont au moins une est transparente ; et
(ii) une couche interne comprenant un polymère (11) et un solvant (12) qui forme une solution homogène dans une gamme de températures sélectionnée au préalable et qui se sépare en phases riche en polymère et riche en solvant à l'extérieur de ladite gamme de températures sélectionée au préalable, lesdites phases riche et polymère et riche en solvant étant ensemble sensiblement moins transmettrices de la lumière que ladite solution homogène;

(b) réunir entre elles les chaînes individuelles dudit polymère par des liaisons interchaînes (13) au niveau de points sur leur longueur ; et
(c) former des liaisons interfaces (14) entre une partie desdites chaînes et lesdites première et seconde couches de recouvrement (10).

24. Un procédé selon la revendication 23 dans lequel l'étape (c) comprend la formation desdites liaisons interfaces (14) entre une partie desdites chaînes et ladite première couche de recouvrement (10) via une couche intermédiaire (21).

25. Un procédé selon la revendication 23, dans lequel l'étape (c) comprend la formation desdites liaisons interfaces (14) entre une partie desdites chaînes et lesdites première et seconde couches de recouvrement (10) via de première et seconde couches de liaison interfaces intermédiaires (21), respectivement.

26. Un procédé de formation d'une structure en couches selon la revendication 23, 24 ou 25, dans lequel ladite première couche de recouvrement (10) et ladite seconde couche de recouvrement (10) sont disposées en étant écartées l'une de l'autre d'un intervalle fixe en définissant ainsi l'épaisseur de ladite couche interne.

27. Un procédé de formation d'une structure en couches selon la revendication 23, dans lequel ladite première couche de recouvrement (10) et ladite seconde couche de recouvrement (10) sont disposées en étant écartées l'une de l'autre d'un intervalle fixe formé par deux cylindres parallèles (34) en définissant ainsi l'épaisseur de ladite couche interne.

28. Un procédé de formation d'une structure en couches selon la revendication 26, dans lequel ladite première couche de recouvrement (10) et ladite seconde couche de recouvrement (10) sont disposées en étant écartées l'une de l'autre d'un intervalle fixe formé par le produit d'extrusion d'une matrice d'extrusion en définissant ainsi l'épaisseur de ladite couche interne.

29. Un procédé de formation d'une structure en couches selon la revendication 26, dans lequel ladite première couche de recouvrement (10) et ladite seconde couche de recouvrement (10) sont disposées en étant écartées l'une de l'autre d'un intervalle fixe formé par une couche interne formée par un couteau sur une machine à enduire à rouleau (33) en définissant ainsi l'épaisseur de ladite couche interne.

30. Un procédé de régulation de la transmission d'énergie solaire dans un bâtiment, ledit procédé comprenant les étapes consistant à :

(1) créer une structure en couches présentant un pouvoir de réflexion de la lumière qui dépend de la température, ladite structure comprenant :

de première et seconde couches de recouvrement (10), dont au moins une transmet la lumière; et
une couche interne comprenant un polymère (11) et un solvant (12) qui forment une solution homogène dans une gamme de températures sélectionnée au préalable et qui se séparent en phases riche en polymère et riche en solvant à l'extérieur de ladite gamme de températures sélectionnée au préalable, lesdites phases riche en polymère et riche en solvant étant ensemble sensiblement davantage réfléchissantes de la lumière que ladite solution homogène;

ledit polymère (11) comprenant des chaînes individuelles réunies entre elles par des liaisons interchaînes (13) au niveau de points sur leur longueur et réunies par de liaisons interfaces (14) auxdites première et seconde couches de recouvrement pour former un réseau desdites liaisons, et lesdites première et seconde couches de recouvrement ainsi que ladite couche interne étant sensiblement non absorbante de lumière, et
(2) placer ladite structure en couches dans le trajet de ladite énergie solaire.

31. Un écran d'affichage capable de former une image sur l'écran à partir d'un motif de températures sur l'écran, comprenant une structure en couches présentant un pouvoir de réflexion de la lumière qui dépend de la température, ladite structure en couches comprenant :

de première et seconde couches de recouvrement (10), dont au moins une transmet de la lumière; et
une couche interne comprenant un polymère (11) et un solvant (12) qui forment une solution homogène dans une gamme de températures sélectionnée au préalable et qui se séparent en phase riche en polymère et riche en solvant à l'extérieur de ladite gamme de températures sélectionnée au préalable, lesdites phases riche en polymère et riche en solvant étant ensemble sensiblement davantage réfléchissantes de la lumière que ladite solution homogène ;
ledit polymère (11) étant composé de chaînes individuelles réunies entre elles par des liaisons interchaînes (13) au niveau de points sur leur longueur et réunies par des liaisons interfaces (14) auxdites première et seconde couches de recouvrement.

FIG. 1

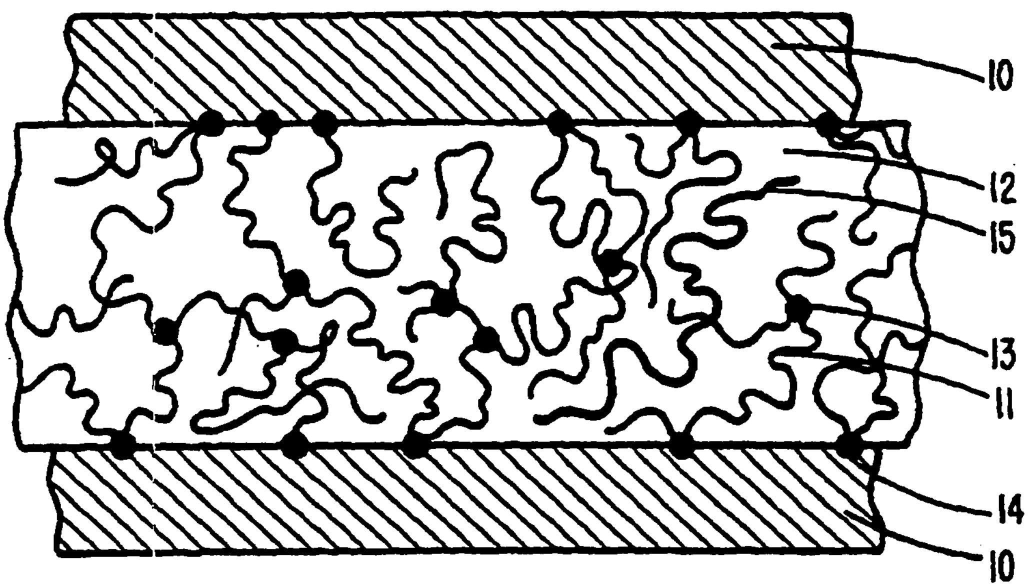


FIG. 2

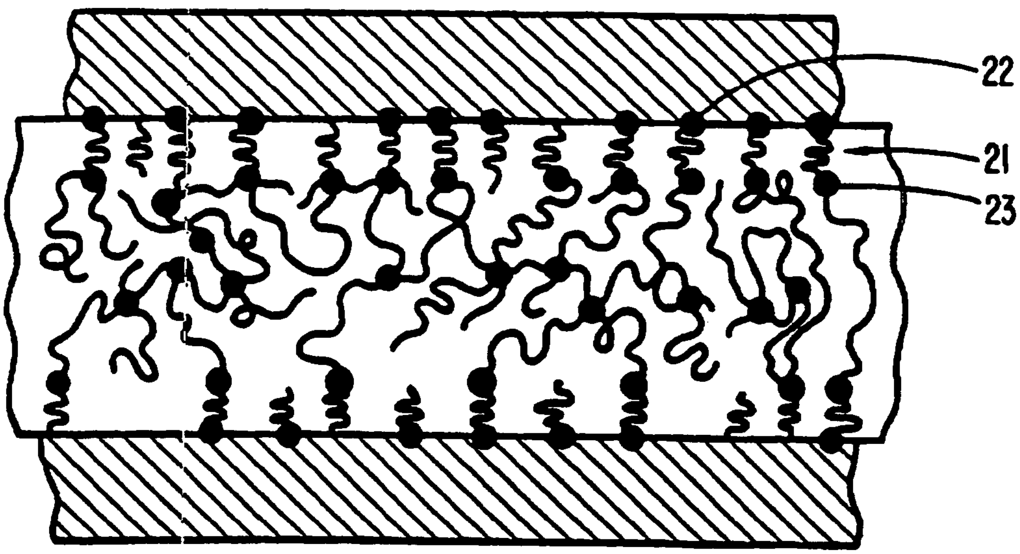
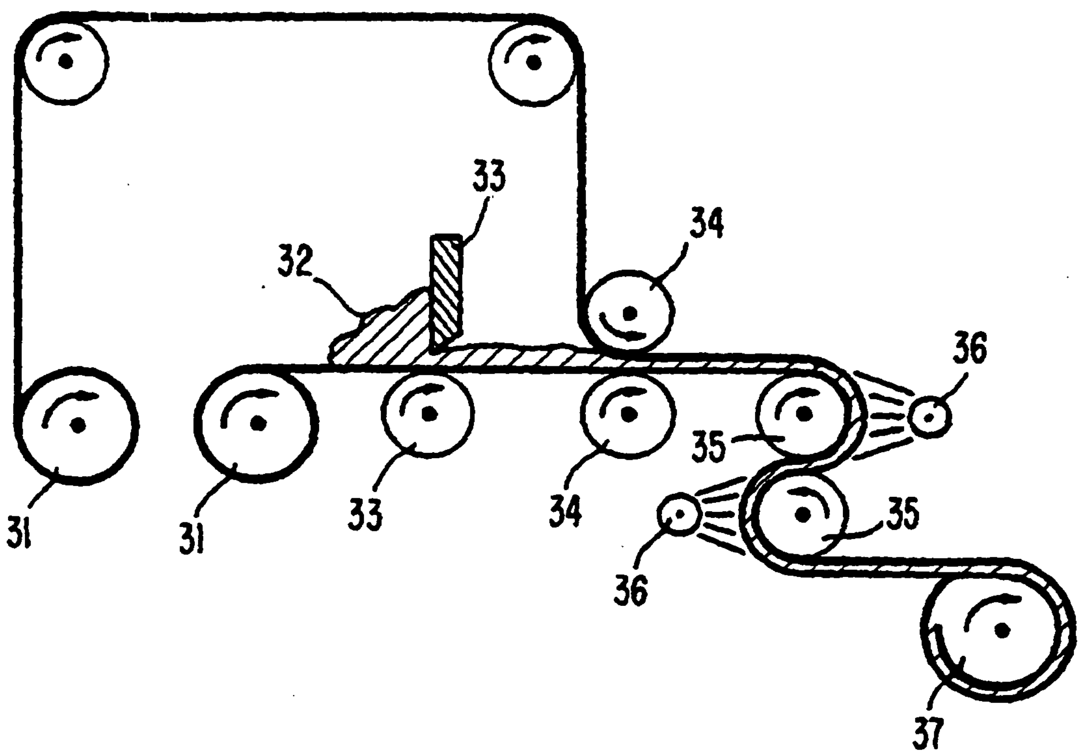


FIG. 3



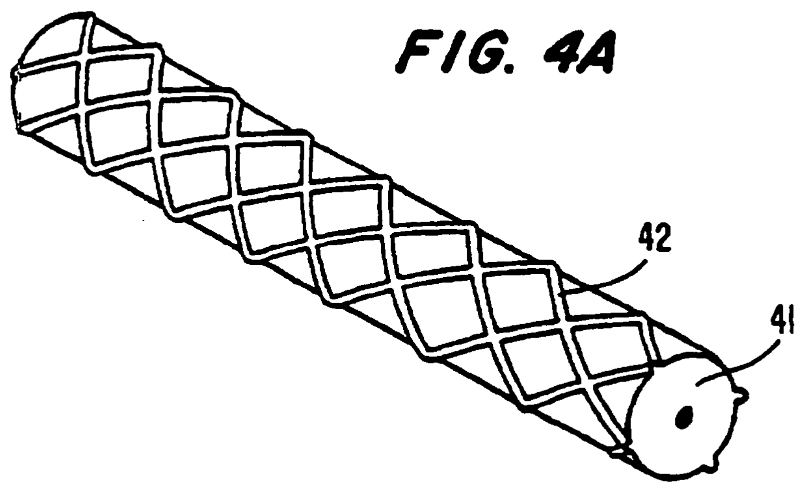


FIG. 4A

FIG. 4B

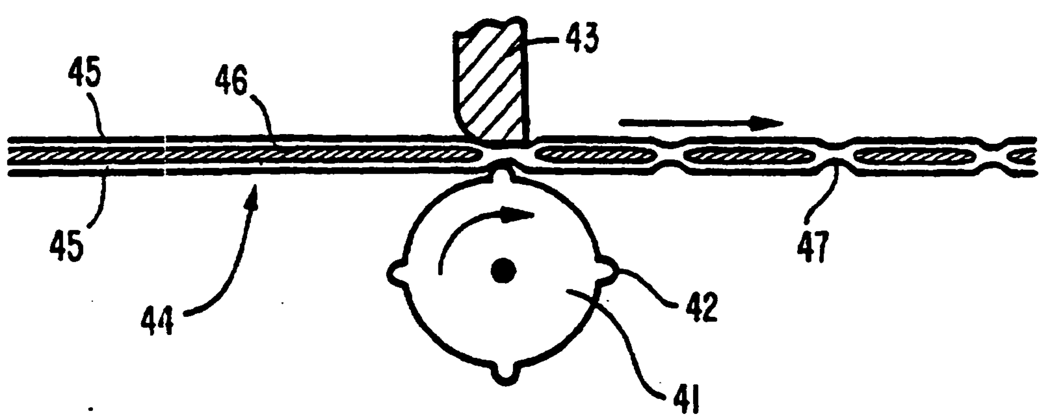
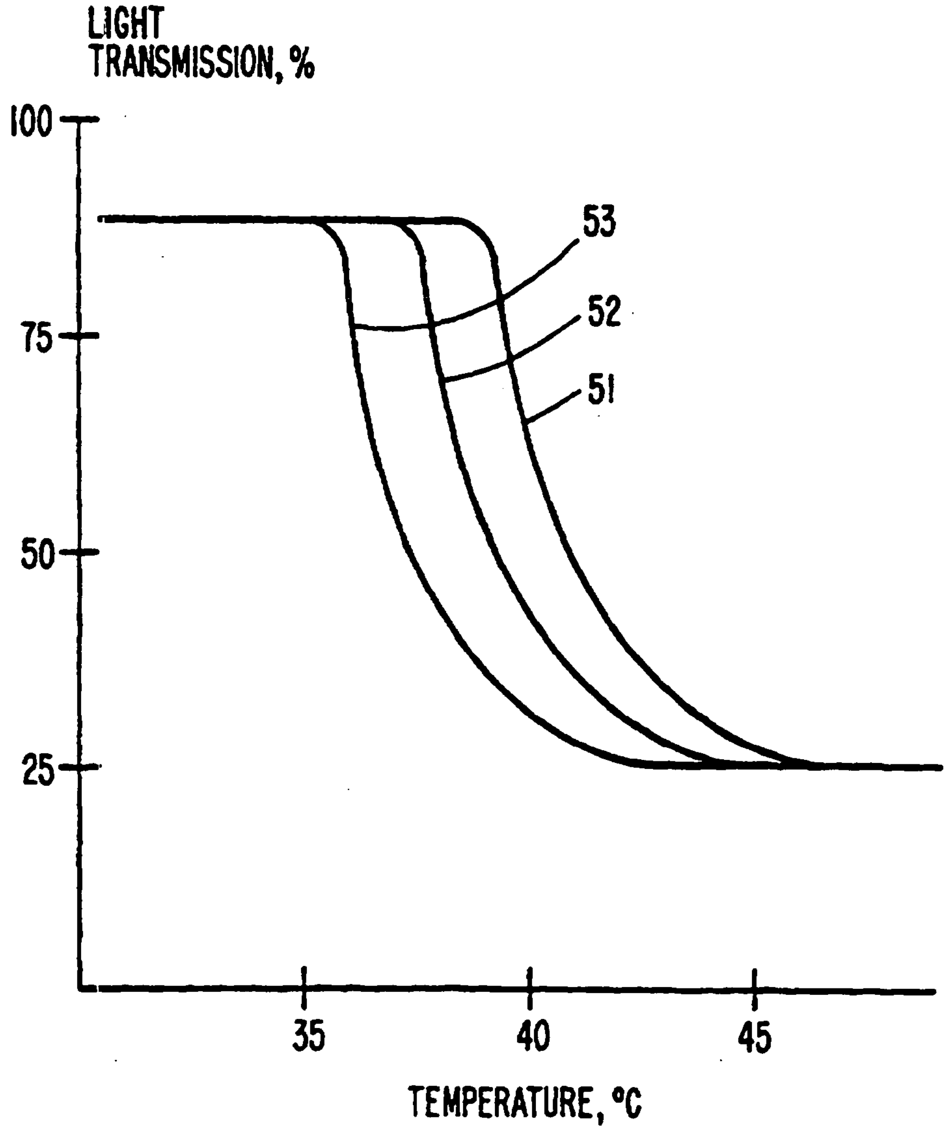


FIG. 5


LIGHT
TRANSMISSION, %
100
75
50
25
53
52
51
35
40
45
TEMPERATURE, °C